

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference P2356-W0	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/GB 00/ 03546	International filing date (day/month/year) 14/09/2000	(Earliest) Priority Date (day/month/year) 14/09/1999
Applicant PEARSON, Frederick		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 4 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☐ the text is approved as submitted by the applicant.

☒ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☐ as suggested by the applicant.

☒ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

1

☐ None of the figures.

INTERNATIONAL PRIORITY REPORT

International application No.

/GB 00/ 03546

Box III .. TEXT OF THE ABSTRACT (Continuation of item 5 of the first sheet)

A process for the treatment of organic matter, comprises the steps of preliminary microwave irradiation in an oxygen-depleted atmosphere to give a black ash-like residue, followed by combustion of the residue to give a white ash. Hence the emissions of carcinogens such as dioxins are substantially reduced as are heavy metals such as Mercury and Cadmium. The apparatus (11) comprises a single chamber (12) in which both steps of the process are performed. The apparatus (11) also comprises means for generating nitrogen-or oxygen-depleted air as well as scrubbers (2), filters, condensers and the like for treating the gaseous products (carbon dioxide and steam) of the process. The apparatus (11) may be of a portable and modular nature - and may optionally include a cremulator.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 00/03546

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 F23G1/00 F23G5/40 F23G5/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 IPC 7 F23G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2 032 596 A (GEORGE ALWYN FREDERICK) 8 May 1980 (1980-05-08) page 1, column 1, line 4 - line 7 page 2, column 1, line 5 -column 2, line 114 figures 1-3	1,2,6, 13,17,29
A	EP 0 318 598 A (MATSUSHITA ELECTRIC IND CO LTD) 7 June 1989 (1989-06-07) page 3, line 12 -page 4, line 13 page 5, line 8 -page 8, line 23 page 9, line 18 -page 10, line 18 page 11, line 5 - line 21 figure 1	1,2,4,6, 11,17,24

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *G* document member of the same patent family

Date of the actual completion of the international search

5 December 2000

Date of mailing of the international search report

13/12/2000

Name and mailing address of the ISA
 European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
 Fax: (+31-70) 340-3016

Authorized officer

Coquau, S

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 00/03546

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>US 5 397 551 A (WON SAM KIM) 14 March 1995 (1995-03-14) column 2, line 45 - line 59 column 5, line 6 -column 6, line 39 column 7, line 31 -column 9, line 46 figure 1</p> <p>-----</p>	1,2,6,17

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 00/03546

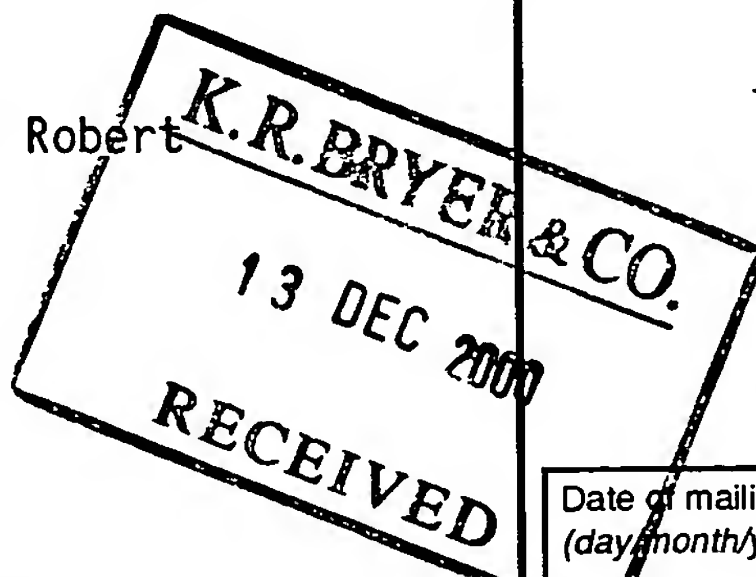
Patent document cited in search report		Publication date	Patent family member(s)	Publication date
GB 2032596	A	08-05-1980	NONE	
EP 0318598	A	07-06-1989	JP 1794184 C	14-10-1993
			JP 4081685 B	24-12-1992
			JP 63318410 A	27-12-1988
			JP 1058919 A	06-03-1989
			JP 1827734 C	28-02-1994
			JP 5036683 B	31-05-1993
			JP 1163514 A	27-06-1989
			JP 1794204 C	14-10-1993
			JP 4081687 B	24-12-1992
			DE 3883719 D	07-10-1993
			DE 3883719 T	16-12-1993
			WO 8810399 A	29-12-1988
			KR 9204825 B	18-06-1992
			US 4937411 A	26-06-1990
US 5397551	A	14-03-1995	FR 2694974 A	25-02-1994
			GB 2269222 A,B	02-02-1994
			DE 4225639 C	13-01-1994

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

To:
K R BRYER & CO
Attn. BRYER, Kenneth Robert
7 Gay Street
Bath-BA1 2PH
UNITED KINGDOM



NOTIFICATION OF TRANSMITTAL OF
THE INTERNATIONAL SEARCH REPORT
OR THE DECLARATION

(PCT Rule 44.1)

Date of mailing
(day/month/year)

13/12/2000

Applicant's or agent's file reference
P2356-W0

FOR FURTHER ACTION See paragraphs 1 and 4 below

International application No.
PCT/GB 00/ 03546

International filing date
(day/month/year)

14/09/2000

Applicant

PEARSON, Frederick

1. ☒ The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:

The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. ☐ The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. ☐ **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

☐ the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90bis.1 and 90bis.3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority



European Patent Office, P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Desirée Vrolijk-Klug

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

PCT

To:

BRYER, Kenneth Robert
K R Bryer & Co
7 Gay Street
Bath BA1 2PH
GRANDE BRETAGNE

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT (PCT Rule 71.1)

Date of mailing
(day/month/year) 16.07.2001

Applicant's or agent's file reference
P2356-WO

IMPORTANT NOTIFICATION

International application No.
PCT/GB00/03546

International filing date (day/month/year)
14/09/2000

Priority date (day/month/year)
14/09/1999

Applicant
PEARSON, Frederick

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.
4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/



European Patent Office
D-80298 Munich
Tel. +49 89 2399 - 0 Tx: 523656 epmu d
Fax: +49 89 2399 - 4465

Authorized officer

Miehle, S



Tel.+49 89 2399-7265



PATENT COOPERATION TREATY
PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference P2356-WO	<div style="display: flex; justify-content: space-between;"><div>FOR FURTHER ACTION</div><div>See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)</div></div>	
International application No. PCT/GB00/03546	International filing date (<i>day/month/year</i>) 14/09/2000	Priority date (<i>day/month/year</i>) 14/09/1999
International Patent Classification (IPC) or national classification and IPC F23G1/00		
Applicant PEARSON, Frederick		
<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 5 sheets, including this cover sheet.</p> <p><input type="checkbox"/> This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of sheets.</p>		
<p>3. This report contains indications relating to the following items:</p> <ul style="list-style-type: none">I <input checked="" type="checkbox"/> Basis of the reportII <input type="checkbox"/> PriorityIII <input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicabilityIV <input type="checkbox"/> Lack of unity of inventionV <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statementVI <input type="checkbox"/> Certain documents citedVII <input type="checkbox"/> Certain defects in the international applicationVIII <input checked="" type="checkbox"/> Certain observations on the international application		
Date of submission of the demand 12/04/2001	Date of completion of this report 16.07.2001	
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Theis, G Telephone No. +49 89 2399 2787 	

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/03546

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):
- Description, pages:**

1-26 as originally filed

Claims, No.:

1-36 as originally filed

Drawings, sheets:

1/7-7/7 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/GB00/03546

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability;
citations and explanations supporting such statement**

1. Statement

Novelty (N)	Yes:	Claims	1-36
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-36
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-36
	No:	Claims	

2. Citations and explanations
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB00/03546

Reference is made to the following documents :

- D1 GB-A-2 032 596
- D2 EP-A-0 318 598

V. Statement under Article 35(2)

- 1) Document D1, which may be considered as the closest prior art, discloses a process (and an apparatus) for the treatment of carbonaceous material comprising the steps of introducing the material, into a chamber having closure means, effecting a preliminary treatment (dessication) of the material by irradiation with microwaves, introducing oxygen and air and a combustible gas into the said chamber, and igniting said combustible gas thereby causing combustion and reduce the residue from the irradiation step to a fine ash. But oxygen is not extracted or displaced from the chamber to provide a substantially oxygen-depleted atmosphere and the microwave treatment only serves to dessicate the remains but is insufficient to cause substantial degradation to an ash-like residue. Hence the subject-matter of claims 1 and 17 is new in the sense of Article 33(2) PCT.

Document D2 shows an apparatus for the treatment of carbonaceous material wherein organic matter is dried and then decomposed by microwave. But this operation does not take place in an oxygen free atmosphere and the combustion of the decomposition gases occurs in a secondary combustion chamber. As the prior art does not disclose the extraction or displacement of oxygen prior to e.m. radiation treatment, a skilled person would not be in a position to derive the claimed invention therefrom without inventive skill. Hence the subject-matter of claims 1 and 17 involves an inventive step in the sense of Article 33(3) PCT.

- 2) The inventions defined in claims 2-16 and 18-36 represent further developments of the invention of claims 1 and 17 respectively. Hence the subject-matter of these claims is new in the sense of Article 33(2) PCT and involves an inventive step in the sense of Article 33(3) PCT.
- 3) The industrial applicability of the claimed invention is obvious.

VIII. Observations on the international application

- 1) To meet the requirements of Rule 5.1 (a) (ii) PCT, relevant prior art documents D1,D2 should have been identified in the description and the background art disclosed therein should have been briefly discussed.
- 2) The features of the claims should have been provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

PATENT COOPERATION TREATY

PCT

REC'D 18 JUL 2001

WIPO

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference P2356-WO	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/GB00/03546	International filing date (day/month/year) 14/09/2000	Priority date (day/month/year) 14/09/1999
International Patent Classification (IPC) or national classification and IPC F23G1/00		
Applicant PEARSON, Frederick		



1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 5 sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

 These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☒ Certain observations on the international application

Date of submission of the demand 12/04/2001	Date of completion of this report 16.07.2001
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Theis, G Telephone No. +49 89 2399 2787 

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/03546

I. Basis of the report

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Description, pages:

1-26 as originally filed

Claims, No.:

1-36 as originally filed

Drawings, sheets:

1/7-7/7 as originally filed

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- ☐ furnished subsequently to this Authority in written form.
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- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

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- ☐ the description, pages:
- ☐ the claims, Nos.:

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/03546

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-36
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-36
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-36
	No:	Claims	

2. Citations and explanations
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB00/03546

Reference is made to the following documents :

- D1 GB-A-2 032 596
- D2 EP-A-0 318 598

V. Statement under Article 35(2)

- 1) Document D1, which may be considered as the closest prior art, discloses a process (and an apparatus) for the treatment of carbonaceous material comprising the steps of introducing the material, into a chamber having closure means, effecting a preliminary treatment (dessication) of the material by irradiation with microwaves, introducing oxygen and air and a combustible gas into the said chamber, and igniting said combustible gas thereby causing combustion and reduce the residue from the irradiation step to a fine ash. But oxygen is not extracted or displaced from the chamber to provide a substantially oxygen-depleted atmosphere and the microwave treatment only serves to dessicate the remains but is insufficient to cause substantial degradation to an ash-like residue. Hence the subject-matter of claims 1 and 17 is new in the sense of Article 33(2) PCT.

Document D2 shows an apparatus for the treatment of carbonaceous material wherein organic matter is dried and then decomposed by microwave. But this operation does not take place in an oxygen free atmosphere and the combustion of the decomposition gases occurs in a secondary combustion chamber. As the prior art does not disclose the extraction or displacement of oxygen prior to e.m. radiation treatment, a skilled person would not be in a position to derive the claimed invention therefrom without inventive skill. Hence the subject-matter of claims 1 and 17 involves an inventive step in the sense of Article 33(3) PCT.

- 2) The inventions defined in claims 2-16 and 18-36 represent further developments of the invention of claims 1 and 17 respectively. Hence the subject-matter of these claims is new in the sense of Article 33(2) PCT and involves an inventive step in the sense of Article 33(3) PCT.
- 3) The industrial applicability of the claimed invention is obvious.

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB00/03546

VIII. Observations on the international application

- 1) To meet the requirements of Rule 5.1 (a) (ii) PCT, relevant prior art documents D1,D2 should have been identified in the description and the background art disclosed therein should have been briefly discussed.
- 2) The features of the claims should have been provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

PCT

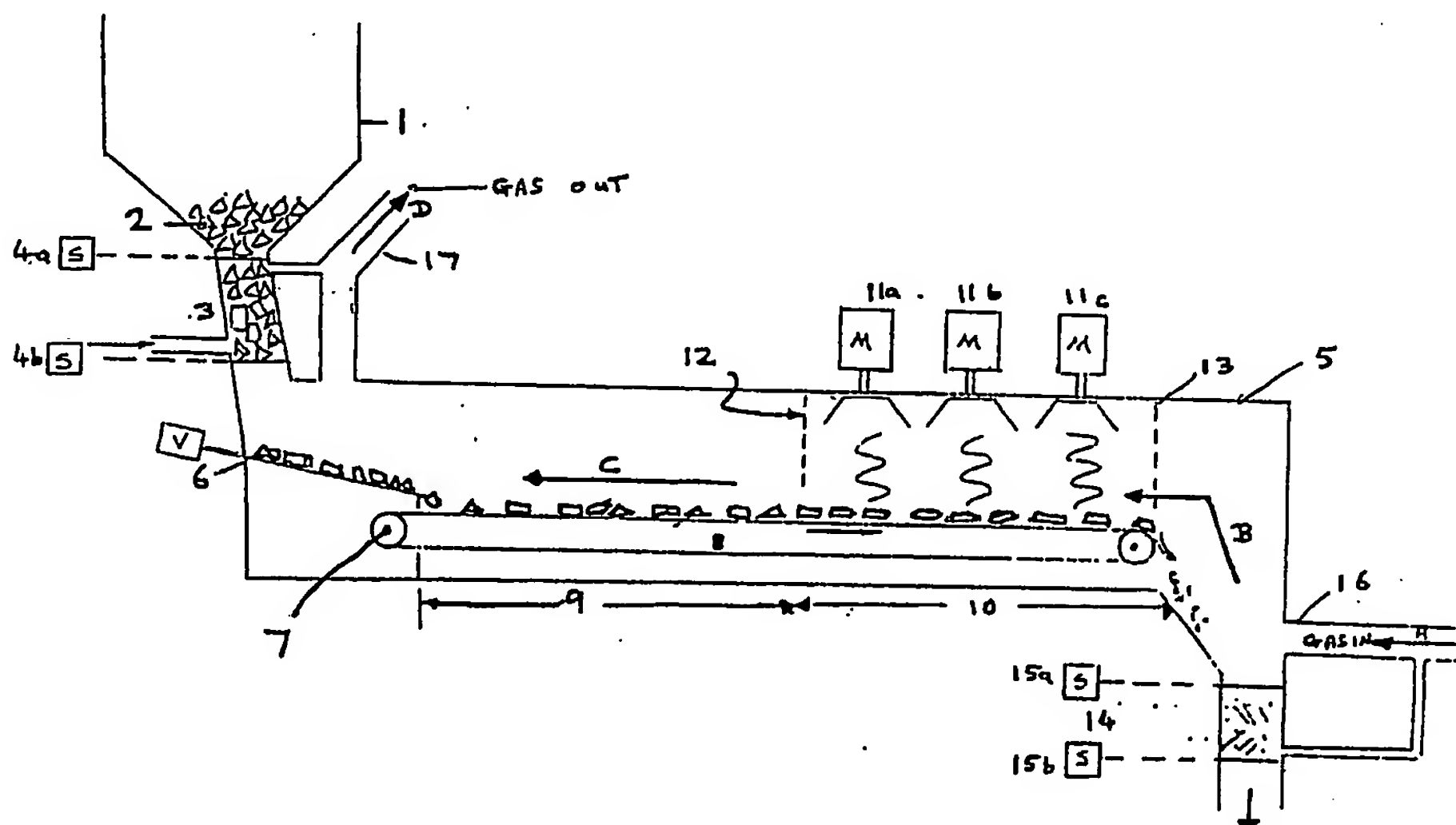
WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁴ : C10B 53/00	A1	(11) International Publication Number: WO 89/ 04355 (43) International Publication Date: 18 May 1989 (18.05.89)
(21) International Application Number: PCT/GB88/00979 (22) International Filing Date: 11 November 1988 (11.11.88) (31) Priority Application Number: 8726397 (32) Priority Date: 11 November 1987 (11.11.87) (33) Priority Country: GB (71)(72) Applicant and Inventor: HOLLAND, Kenneth, Michael [GB/GB]; Ashwood, Wynwoods, Campbell Close, Rise Park, Ronford, Essex (GB). (74) Agents: AUSTIN, Hedley, William et al.; Urquhart-Dykes & Lord, Alexandra House, Alexandra Road, Swansea SA1 5ED (GB).		(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB, GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US. Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

(54) Title: **PYROLYSIS OF ORGANIC MATERIAL**



(57) Abstract

The organic material (such as waste tyre compound) is pyrolysed by pre-heating the organic material (without pyrolysis) in a preheat zone (9) by a hot gas stream; feeding pre-heated material directly to a microwave discharge zone (10) by means of a conveyor (8); pyrolysing the pre-heated material in the microwave discharge zone to produce solid fission products containing elemental carbon and gaseous by-products; and recycling at least some of the latter to the hot gas stream which is supplied to the pre-heating zone.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	FR	France	ML	Mali
AU	Australia	GA	Gabon	MR	Mauritania
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Pyrolysis of Organic Material

The present invention is concerned with the destructive distillation (or pyrolysis) of organic material, and particularly (but not exclusively), the pyrolysis of waste tyre material or other similar rubber compounds.

A process of pyrolysing organic waste by means of microwaves is disclosed in U.S. Patent 3843457; in this process organic industrial and household wastes are comminuted and the comminuted solid material is subjected to a microwave discharge in a gas stream at a pressure substantially less than atmospheric for a contact time of the order of one second. The gas stream and the comminuted solid material pass through the microwave zone in parallel, with a view to maximising interaction between the gas and the solid.

Microwave destruction of waste tyre material has also been disclosed in, for example, (examined) Japanese Patent Applications 76/47192-3, 77/26553, 82/3491 and (unexamined) Japanese patent applications 52/3672 and 51/123287. These documents describe laboratory scale processes, in which small quantities of the waste rubber are subjected to microwave discharge so as to completely break the rubber down and produce carbon black and hydrocarbons (gaseous or liquid). These documents give no details as to how the basic idea of microwave pyrolysis could be converted into a commercial process.

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A more recent document, U.S. Patent 4647443, discloses a process of pyrolysing of waste tyre material which involves subjecting the tyre material to radiant heating so as to produce a pyrolysed char, and then subjecting the char to microwave discharge to remove volatile hydrocarbons from the char, so as to produce carbon black.

The disadvantage of this process is that radiant heating of tyre material involves relatively inefficient heat transfer. I have found that, contrary to the teaching of U.S. Patent 4647443, it is advantageous to pre-heat tyre material (and other organic materials), without pyrolysis thereof, prior to complete pyrolysis by means of microwaves. That is, microwave-induced pyrolysis has been found to be impaired if tyre material (or other organic material) has previously been partly pyrolysed (this is postulated to be because of the insulating effect of the elemental carbon produced on pyrolysis). It is believed that this may be why the U.S. patent teaches that the pyrolysis should be taken to substantial completion in the radiant heating stage.

I have now found that, in contradistinction to the teaching of U.S. Patent 4647443, it is advantageous to completely avoid pyrolysis in a pre-heating stage prior to microwave-induced pyrolysis.

The process according to the invention enables microwave pyrolysis of waste tyre material and other rubber compounds, as well as other organic materials, to be operated as a commercial destructive distillation process.

According to the present invention, therefore, there is provided a process of destructive distillation of organic material, which comprises:

- (a) pre-heating said organic material, substantially without pyrolysis of said organic material to elemental carbon, by means of a hot gas stream;

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- (b) feeding said pre-heated material directly to a microwave discharge zone in an atmosphere of substantially oxygen-free gas which is above atmospheric pressure;
- (c) pyrolysing said pre-heated material in said zone by means of a microwave discharge of sufficient power, and for a sufficient time, to cause substantial fission of carbon-carbon bonds in the organic material, in addition to fission of more polar chemical bonds, so as to produce solid fission products containing elemental carbon, and gaseous by-products;
- (d) collecting said solid fission products downstream of said microwave discharge zone; and
- (e) recycling at least part of said gaseous by-products to said hot gas stream to effect said pre-heating.

The process according to the invention can be operated as a continuous process, as will be explained hereinafter.

It should, perhaps, be mentioned that a process involving the continuous microwave treatment of waste rubber material is known; see, for example, U.S. Patents 4104205 and 4129768, which are both concerned with devulcanisation of the rubber (that is, fission of carbon-sulphur bonds, but not of carbon-carbon bonds in the molecular structure). U.K. patent specifications 2028835 and 1513656 are similarly concerned with devulcanisation of rubber compounds by means of microwave irradiation. There is no hint or suggestion in any of these documents of the use of the conditions employed in the process according to the present invention for the purpose of substantial breakdown of carbon-carbon bonds.

In one embodiment of the invention, it is preferred that gaseous by-products should be recycled to function as the above-mentioned gas stream; it is also preferred that products in the nature of oils or other liquids

should be collected and, where appropriate, used as fuels to provide at least some of the energy input into the process.

The process according to the invention is directly contrary to the process described in U.S. Patent 3843457, in which it is suggested that in order to recover valuable products from solid waste which contains organic materials, one should subject the waste to microwave discharge while at reduced pressure and at less than 200°C; this appears to be because the waste material envisaged by the patentee comprises carbohydrates of which molecular fragments are reacted with an ionised gas, ionisation being caused by the microwave discharge.

In the process according to the invention, the material being subjected to destructive distillation is such that it contains a substantial proportion of carbon-carbon bonds (such as a hydrocarbon or carbohydrate material). Examples of such materials include natural or synthetic rubber compounds, and agricultural waste material such as citrus fruit peel, olive waste products, and nut shell (e.g. coconut shell), and animal waste (such as sewage, slurry or the like). The organic material is generally such that the solid fission products produced predominantly comprise elemental carbon.

In some embodiments (and particularly where the material being pyrolysed is a rubber compound), it is preferred that the organic material subjected to microwave discharge in the process according to the invention should contain carbon filler; a particularly preferred such material is waste tyre material. Waste tyre material pyrolysed according to the present invention may be in bulk or finely divided form (e.g. chopped form or pulverulent form). Such a material may contain, in addition to carbon filler, organic textile reinforcement and/or metal wire (e.g. steel wire) reinforcement.

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When an organic textile material is employed, the latter is generally substantially carbonised in the discharge zone; when metal wire reinforcement is employed, the latter wire is substantially unaffected by the microwave discharge and is therefore collected together with the solid fission products.

In the process according to the present invention, the waste material is preferably pre-heated by means of the gas stream to a temperature of at least 250°C (such as 300 to 500°C) before being subject to the microwave discharge. It is particularly preferred that both the pre-heating stage and the microwave discharge stage should be carried out in a vessel (which is preferably thermally insulated and of suitable pressure rating) through which the organic material is passed on a conveyor in a continuous manner.

Typically, the same conveyor is used to forward the organic material through the pre-heating zone, to feed the pre-heated material to said microwave discharge zone, and to forward the pre-heated material through the microwave discharge zone. Such a conveyor may be, for example, an endless belt comprising stainless steel or the like.

Generally, it is preferred that the pre-heating zone and the microwave zone each have a purge lock both for supply of the organic material and for removal of solid fission products therefrom so as to substantially prevent inflow of oxygen-containing gas into the respective zone.

The gas stream used in the process according to the invention (which may be supplied in a countercurrent relative to the feed of organic material through the microwave discharge zone, or fed in the same direction) may additionally contain a separately supplied hydrocarbon or inert gas such as nitrogen, as well as at least some of the gaseous products of the destructive distillation. The gas stream may be continuously recirculated to the microwave discharge zone

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(preferably after scrubbing of the gas) and is in some embodiments (for example, where it is desirable to minimise microwave power input) at a temperature of at least 250°C (such as 300 to 500°C) when entering the microwave discharge zone.

The microwave discharge used in the process according to the invention may be in the low gigahertz frequency range (e.g. about 2.4 gigahertz). The duration of the microwave irradiation phase is typically about 15 to 60 minutes; this will depend largely on the nature of the material to be pyrolysed.

Reference will now be made to the accompanying drawings, in which:

Figure 1 is a schematic illustration of an exemplary embodiment of the pyrolysis process according to the invention; and

Figure 2 is a more detailed flow diagram of a further embodiment of the process according to the invention.

Referring to Figure 1, there is shown a feed hopper 1 which is charged with chopped waste rubber material 2. Towards the base of hopper 1 is a purge lock 3 comprising an upper gate 4a and a lower gate 4b, which can be operated so as to prevent, or at least minimise, inflow of air when the rubber material is charged to an insulated vessel 5.

As rubber material is charged from the hopper 1, it falls into a vibrating feed and spreader 6, which itself causes the chopped material to be forwarded to the drive end 7 of belt-type conveyor 8 where the material is preferably spread as a bed of a predetermined depth. As illustrated, the drive end of the conveyor 8 is located in a pre-heating zone 9 of the vessel 5. In the pre-heating zone, the chopped material is typically raised to a temperature in the range 300 to 500°C.

Downstream of the pre-heating zone 9 is a microwave discharge zone 10 having a plurality of microwave

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sources 11a, 11b, 11c. These sources may be all of substantially similar power output, or, alternatively, of graduated power output (for example, of gradually increasing power output with distance from the pre-heating zone 9). The microwave zone 10 is separated from the pre-heating zone 9 by a microwave shield 12; there is a further such shield 13 downstream of the conveyor 8. Further downstream still is a second purge lock 14 comprising an upper gate 15a and a lower gate 15b; solids from the downstream end of the conveyor 8 pass directly to the second purge lock, from where solids produced may be collected.

The vessel 5 is further provided with a gas inlet 16 for hot circulating gas, which passes in the direction of arrows A,B,C,D, and a gas outlet 17 for the gas. The gas supply is controlled such that the gas pressure in the vessel is superatmospheric. In the illustrated embodiment of Figure 1, the inlet 16 and the outlet 17 are so arranged that the gas flows in countercurrent through the microwave discharge zone 10 and then through the pre-heating zone 9.

Referring to Figure 2, there is shown a process in which waste tyre material 18 is fed to a shredder 20 and the shredded material passed by a feed conveyor 22 to a hopper 24 (oversized material being recycled via line 25 to shredder 20) and then via purge chamber 26 having a series of three purge lock gates 27 to a reactor 28 having a heat resistant conveyor 30 passing therethrough. The conveyor 30 extends from a first upstream end 32 of the reactor 28, which functions as a pre-heating zone, to a second, downstream end 34 provided with microwave sources 36, in which the tyre material is pyrolysed to fission products containing elemental carbon.

The fission products pass from the downstream end 34 of the reactor 28, through a further purge chamber 38 having a series of three purge lock gates 39, via crush rolls 40 to a magnetic separation zone 40, from which steel scrap is collected

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at outlet 42; the remaining pyrolysed material is passed through a cooling zone 44 to be collected downstream at 46.

Nitrogen is fed via lines 48 and 50 to each of the purge chambers 26 and 38 so as to ensure that there is an oxygen-free atmosphere, at superatmospheric pressure, in the reactor 28.

The reactor 28 is further provided with a gas circulation circuit, in which gas is introduced via inlet 52 upstream of the downstream end 34 of the reactor, and allowed to exit via outlet 54 downstream of the microwave zone. From outlet 54, the gas passes to a quench cooler 56 and thence to a quench column 58.

Bottoms from the latter are recycled via recirculating oil pump 60, filter 62, and oil cooler 64 to the top 66 of quench cooler 56, part of the stream from the filter 62 being passed to stripper 68 supplied with steam 70. Bottoms from the stripper 68 are passed via oil pump 72 and heat exchanger 73 to storage tank 74; volatiles from the stripper 68 are recycled to quench column 58. Volatiles from column 58 are passed via heat exchanger 76 to decanter 78, where separation is effected into effluent 80 (for disposal), liquids 82 (passed via pump 84 to storage tank 86 for mixing with oil from tank 74) and gases 88. A portion of the gas is recycled via blower 90 and gas heater 92 to inlet 52; the remainder of the gas is drawn off at 94 to be used for power generation or the like. (In Figure 2, "CW" represents the supply of cooling water to the respective heat exchanger.)

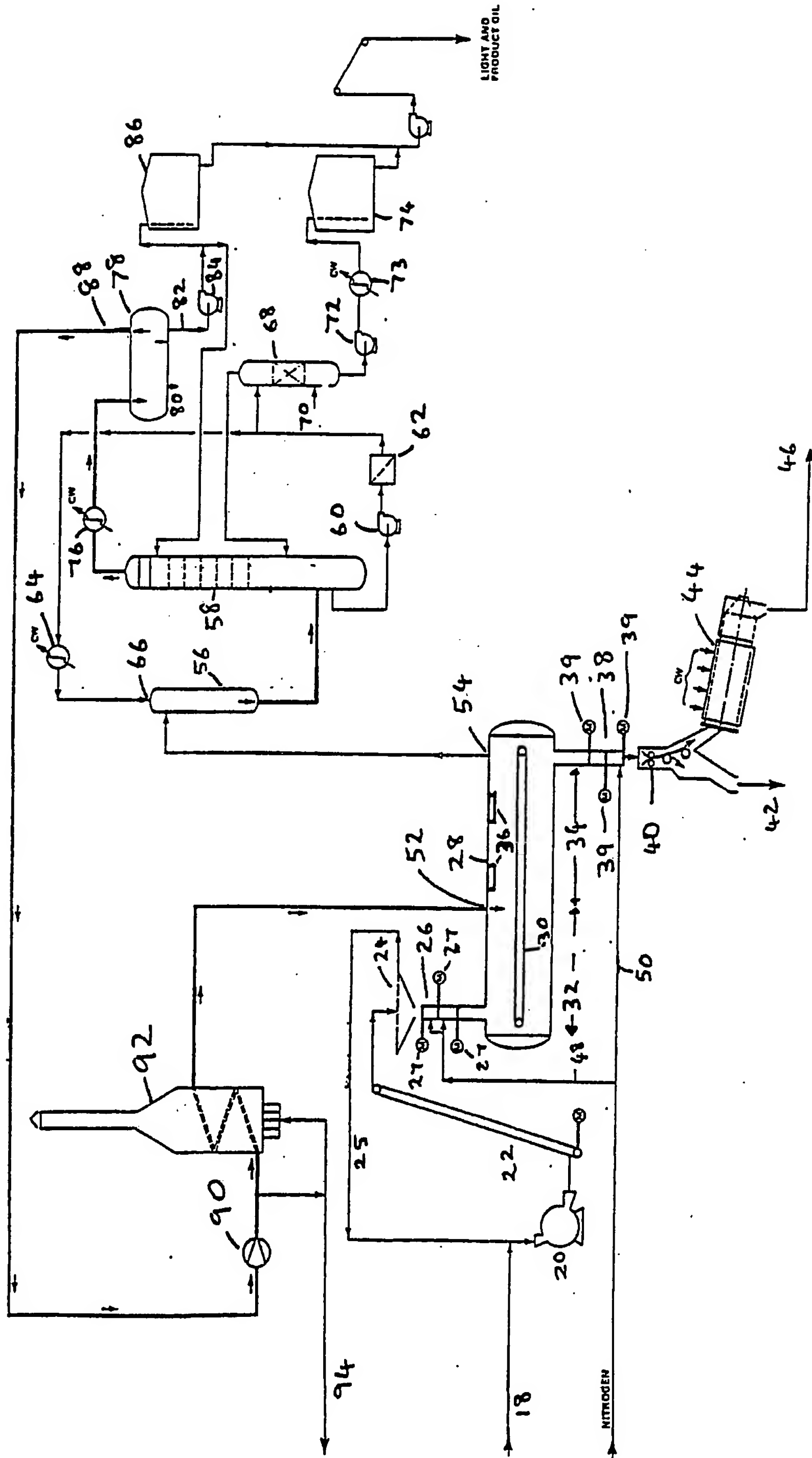
CLAIMS:

1. A process of destructive distillation of organic material, which comprises:
 - (a) pre-heating said organic material, substantially without pyrolysis of said organic material to elemental carbon, by means of a hot gas stream;
 - (b) feeding said pre-heated material directly to a microwave discharge zone in an atmosphere of substantially oxygen-free gas which is above atmospheric pressure;
 - (c) pyrolysing said pre-heated material in said zone by means of a microwave discharge of sufficient power, and for a sufficient time, to cause substantial fission of carbon-carbon bonds in the organic material, in addition to fission of more polar chemical bonds, so as to produce solid fission products containing elemental carbon, and gaseous by-products;
 - (d) collecting said solid fission products downstream of said microwave discharge zone; and
 - (e) recycling at least part of said gaseous by-products to said hot gas stream to effect said pre-heating.
2. A process according to claim 1, in which the same feed means is used to forward said organic material through the pre-heating zone, to feed said pre-heated material to said microwave discharge zone, and to forward said material through said microwave discharge zone.
3. A process according to claim 1 or 2, in which the pre-heating zone and the microwave zone each have a purge lock for respective supply and removal of solid material therefrom without inflow of oxygen-containing gas into the respective zone.

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4. A process according to any of claims 1 to 3, wherein said gas stream comprises substantially the entirety of gaseous by-products, passed in countercurrent to the feed of said organic material.
5. A process according to any of claims 1 to 3, wherein said gas stream comprises at least part of said gaseous by-products which have been recycled such that the gas stream and the organic material pass through the microwave discharge zone in the same direction.
6. A process according to claim 4 or 5, wherein said gas stream further comprises separately supplied hydrocarbon or nitrogen.
7. A process according to any of claims 1 to 6, wherein liquid by-products from the microwave discharge zone are burnt and the resultant thermal energy is used to provide at least some of the energy input into the process.
8. A process according to any of claims 1 to 7, in which said organic material predominantly comprises hydrocarbon and/or carbohydrate materials.
9. A process according to any of claims 1 to 8, wherein said organic material comprises a rubber compound, preferably containing carbon filler.
10. A process according to claim 8, wherein said organic material comprises waste matter derived from animals or plants.

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INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 88/00979

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) *		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC ⁴ : C 10 B 53/00		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC ⁴	C 10 B	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched *		
III. DOCUMENTS CONSIDERED TO BE RELEVANT *		
Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
Y	US, A, 4647443 (APFFEL) 3 March 1987, see claims 1,15-24; figure 1A (cited in the application) --	1,3-10
Y	US, A, 3843457 (GRANNEN et al.) 22 October 1974, see claims 1,2,5,7-9; column 2, lines 62-70 (cited in the application) --	1,3-10
A	US, A, 3449213 (KNAPP et al.) 10 June 1969, see claim 1; figure 3 --	1
A	Database WPIL, Derwent, see abstract no. 73-66277U & JP, B, 76047192 (AGENCY OF IND. SCIENCES AN) 12th December 1976 (cited in the application) -----	1
<p>* Special categories of cited documents: ¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
15th February 1989	14. 03. 89	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	P.C.G. VAN DER PUTTEN	

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.

GB 8800979
SA 25388

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 03/03/89
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4647443	03-03-87	None	
US-A- 3843457	22-10-74	None	
US-A- 3449213	10-06-69	US-A- 3523405	11-08-70
		US-A- 3560347	02-02-71

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82